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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/591,417	09/01/2006	James Rabreau	GRIF-006XX	2528
207 7590 05/11/2010 WEINGARTEN, SCHURGIN, GAGNEBIN & LEBOVICI LLP TEN POST OFFICE SQUARE BOSTON, MA 02109				
EXAMINER TAVLYKAEV, ROBERT FUATOVICH				
ART UNIT 2883		PAPER NUMBER		
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**Please find below and/or attached an Office communication concerning this application or proceeding.**

The time period for reply, if any, is set in the attached communication.

### Office Action Summary

**Application No.**

10/591,417

**Applicant(s)**

RABEAU ET AL.

**Examiner**

ROBERT TAVLYKAEV

**Art Unit**

2883

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --  
**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

- 1) ☒ Responsive to communication(s) filed on 02 February 2010.  
2a) ☐ This action is **FINAL**. 2b) ☒ This action is non-final.  
3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

**Disposition of Claims**

- 4) ☒ Claim(s) 1-44 is/are pending in the application.  
4a) Of the above claim(s) 11, 13, 18-20, 25 and 32 is/are withdrawn from consideration.  
5) ☐ Claim(s) \_\_\_\_\_ is/are allowed.  
6) ☒ Claim(s) 1-10, 12, 14-17, 21-24, 26-31, 33-44 is/are rejected.  
7) ☐ Claim(s) \_\_\_\_\_ is/are objected to.  
8) ☐ Claim(s) \_\_\_\_\_ are subject to restriction and/or election requirement.

**Application Papers**

- 9) ☐ The specification is objected to by the Examiner.  
10) ☒ The drawing(s) filed on 01 September 2006 is/are: a) ☐ accepted or b) ☒ objected to by the Examiner.  
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).  
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).  
11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

**Priority under 35 U.S.C. § 119**

- 12) ☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).  
a) ☒ All b) ☐ Some \* c) ☐ None of:  
1. ☒ Certified copies of the priority documents have been received.  
2. ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.  
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

\* See the attached detailed Office action for a list of the certified copies not received.

**Attachment(s)**

- 1) ☒ Notice of References Cited (PTO-892)  
2) ☐ Notice of Draftsman's Patent Drawing Review (PTO-948)  
3) ☒ Information Disclosure Statement(s) (PTO/SB/08)  
Paper No(s)/Mail Date 9/7/06, 6/9/09  
4) ☐ Interview Summary (PTO-413)  
Paper No(s)/Mail Date: \_\_\_\_\_  
5) ☐ Notice of Informal Patent Application  
6) ☐ Other: \_\_\_\_\_

## **DETAILED ACTION**

### ***Election/Restrictions***

1. Applicant's election with traverse of subgroups A2, B1, C1, D1, and E2 in the reply filed on 2/2/10 is acknowledged. The traversal is on the ground(s) that prosecution of all elements is not an undue burden, since only a very limited number of claims are excluded. This is not found persuasive because the number of claims is not directly related to a needed breadth of search and a related burden. The requirement is still deemed proper and is therefore made FINAL.

### ***Drawings***

2. The drawings are objected to because Figs. 2a and 2b are too dark and lack contrast to show enough/any details. Corrected drawing sheets in compliance with 37 CFR 1.121(d) are required in reply to the Office action to avoid abandonment of the application. Any amended replacement drawing sheet should include all of the figures appearing on the immediate prior version of the sheet, even if only one figure is being amended. The figure or figure number of an amended drawing should not be labeled as "amended." If a drawing figure is to be canceled, the appropriate figure must be removed from the replacement sheet, and where necessary, the remaining figures must be renumbered and appropriate changes made to the brief description of the several views of the drawings for consistency. Additional replacement sheets may be necessary to show the renumbering of the remaining figures. Each drawing sheet submitted after the filing date of an application must be labeled in the top margin as either "Replacement Sheet" or "New Sheet" pursuant to 37 CFR 1.121(d). If the changes are not accepted by the examiner,

the applicant will be notified and informed of any required corrective action in the next Office action. The objection to the drawings will not be held in abeyance.

### *Claim Objections*

3. Claim 17 is objected to because of the following informalities:

Claim 17 includes the limitation "having photonic bandgap", which appears to be missing the article "a". For the purposes of this Action, the limitation is interpreted as -- having a photonic bandgap. Appropriate corrections are required.

### *Claim Rejections - 35 USC § 112*

4. The following is a quotation of the second paragraph of 35 U.S.C. 112:

The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

Claim 24 recites the limitation "the length of the waveguide". There is insufficient antecedent basis for this limitation in the claim. For the purposes of this Action, the limitation is interpreted as -- a length of the waveguide.

Claim 31 recites the limitation "the additional step". There is insufficient antecedent basis for this limitation in the claim. For the purposes of this Action, the limitation is interpreted as -- an additional step.

Claims 38 and 39 recite the limitation "the step of splicing". There is insufficient antecedent basis for this limitation in the claim. For the purposes of this Action, the limitation is interpreted as -- a step of splicing.

Appropriate corrections are required.

***Claim Rejections - 35 USC § 103***

5. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

The factual inquiries set forth in *Graham v. John Deere Co.*, 383 U.S. 1, 148 USPQ 459 (1966), that are applied for establishing a background for determining obviousness under 35 U.S.C. 103(a) are summarized as follows:

1. Determining the scope and contents of the prior art.
2. Ascertaining the differences between the prior art and the claims at issue.
3. Resolving the level of ordinary skill in the pertinent art.
4. Considering objective evidence present in the application indicating obviousness or nonobviousness.

6. This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

**7. Claims 1 – 3, 7 – 10, 12, 14 – 17, 21 – 24, 26, 28 – 30, 34, and 40 – 44 are rejected under 35 U.S.C. 103(a) as being unpatentable over Lee et al (US Pat. # 6,819,845 B2) in view of “Room temperature stable single-photon source” by Beveratos et al, European Physical Journal D, vol. 18, No. 2, 2002, pp. 191 – 196 (hereinafter Beveratos 1).**

Regarding claims 1 – 3, 7 – 10, 12, 21, 22, 26, 28 – 30, 34, and 40 – 44, Lee discloses (e.g., Figs. 4B, 17, and 27) a photon source (col. 9, lines 40 – 45) and a corresponding method of making thereof, the photon source comprising:

an optical waveguide (e.g., Figs. 17 and 27) and

a nanomaterial comprising at least one quantum dot center (e.g., Abstract), the nanomaterial having been grown so that the nanomaterial is bonded to, or alternatively or additionally, incorporated in the optical waveguide and in use at least some of the photons emitted by the or each quantum dot center are guided in the optical waveguide. Lee contemplates that the nanomaterial can be grown (col. 54, lines 58 – 60; col. 59, lines 42 – 47), for example, on a portion of a core region of the waveguide (e.g., Fig. 17; Abstract). Further, Lee cites (col. 14, line 44 through col. 15, line 32) a variety of possible nanomaterials for use as quantum dots but does not expressly teach that alternatively a material comprising at least one color center can be used. However, Beveratos 1 describes (e.g., Sections 1 and 2) a photon source that uses a nanomaterial comprising at least one color center. In particular, Beveratos 1 describes the use of nitrogen-vacancy color centers in diamond nanocrystals and expressly cites (5<sup>th</sup> sentence of the par. bridging pages 191 and 192) diamond nanocrystals can be deposited on an optical fiber (on a fiber endface). The Examiner notes that optical fibers are well known to be a particular case of an optical waveguide structure (e.g., col. 10, lines 39 - 48 of Lee). Beveratos 1 also cites (Section

1) a well-known fact about NV color centers in diamond, i.e., that they can be used to emit single photons. Further for claims 40 – 44, Beveratos 1 states (2<sup>nd</sup> par. of Section 2) that NV color centers can be formed, after a step of base material deposition/growth, by irradiation with electrons in order to create vacancies. In light of the foregoing, it would have been obvious to a person of ordinary skill in the art that the photon source disclosed by Lee can alternatively use a nanomaterial comprising color centers, as detailed by Beveratos 1. The motivation is that color centers can enable single photon sources which are well-known to be needed in advanced communication systems based on quantum cryptography, including quantum key distribution systems (Section 1 of Beveratos 1). As relevant comments, the Examiner notes that (i) Beveratos 1 cites both quantum dots and NV color centers as candidates for single photon sources (3<sup>rd</sup> par. of Section 1) and that (ii) quantum dots and color centers are in the same general family of optical dipoles.

**Regarding claims 14 - 16**, Lee cites (e.g., col. 10, lines 12 – 38; col. 71, lines 13 – 18) the well-known fact that a typical waveguide comprises a core region and a core-surrounding region (cladding) that has a lower refractive index than the core region and enables light confinement and guiding in the core region.

**Regarding claims 17**, Lee contemplates (e.g., col. 71, line 50 through col. 72, line 37) the use of photonic crystal structures (which are well known in the art) in the single-photon source disclosed by the Lee – Beveratos 1 combination.

**Regarding claims 23 and 24**, the Lee – Beveratos 1 combination either teaches expressly or renders obvious all of the subject matter.

**8. Claims 4 - 6 are rejected under 35 U.S.C. 103(a) as being unpatentable over Lee et al (US Pat. # 6,819,845 B2) in view of “Room temperature stable single-photon source” by Beveratos et al, European Physical Journal D, vol. 18, No. 2, 2002, pp. 191 – 196 (hereinafter Beveratos 1), and further in view of “Single photon quantum cryptography,” by Beveratos et al, arXiv online publication, available since 19 June 2002 (hereinafter Beveratos 2).**

Regarding claims 4 – 6, the Lee – Beveratos 1 combination teaches all of the subject matter, except for pointing out that the disclosed photon source comprising color centers can be arranged to emit entangled photons, even though schemes for generating polarization-entangled photon pairs are well known in the art. In this regard, Beveratos 2 describes 9Fig. 1; 4<sup>th</sup> par. on the front page) a photon source that is arranged to generate polarization-entangled photon pairs via a 4-state polarization encoding scheme. Beveratos 2 points out (last par. on 3<sup>rd</sup> page) that the described scheme compares favorably with other reported QKD experiments using pairs of entangled photons. Therefore, it would have been obvious to a person of ordinary skill in the art that the photon source with color centers, as disclosed by the Lee – Beveratos 1 combination, can be used for emission of entangled photons, as described by Beveratos 2. The motivation is that secure optical communication systems can be enabled and prevent undetected eavesdropping.

**9. Claims 27, 31, 33, 35 – 39 are rejected under 35 U.S.C. 103(a) as being unpatentable over Lee et al (US Pat. # 6,819,845 B2) in view of “Room temperature stable single-photon source” by Beveratos et al, European Physical Journal D, vol. 18, No. 2, 2002, pp. 191 – 196 (hereinafter Beveratos 1) and further in view of Shields et al (GB Pub. # 2377551 A).**



**Regarding claims 31 and 33**, both Lee and Beveratos 1 contemplate disposing the nanomaterial in an optical resonator cavity. Specifically, Lee teaches (e.g., col. 59, lines 28 – 30) that the nanomaterial can be disposed in a solid etalon cavity, while Beveratos 1 states (5<sup>th</sup> sentence of the par. bridging pages 191 and 192) that the diamond nanomaterial can be disposed in a cavity. However, the Lee – Beveratos 1 combination neither details nor illustrates possible embodiments having a nanomaterial disposed in an optical cavity. In this regard, Shields illustrates (Fig. 4) a photon source that can be a single photon source (2<sup>nd</sup> par. on page 1) and be used in quantum cryptology systems (Abstract), the source including a nanomaterial (comprising at least one quantum dot) disposed in an optical resonator cavity, the latter being attached to an optical waveguide (fiber) so that the photons emitted by the at least one quantum dot are guided by the optical waveguide. While Fig. 4 shows that a separately formed cavity is attached to an endface of an optical waveguide, it would be obvious to a person of ordinary skill in the art that such cavity can be formed integrally with the optical waveguide and be a part thereof, for example, by being placed in a recess formed in the optical waveguide and in particular, in the core region thereof so that emitted light can travel directly into the core region and be guided by it. Etching is well known in the art to be used for forming recesses in optical waveguides, including fibers. In light of the foregoing, it would have been obvious to a person of ordinary skill in the art that the nanomaterial of the single photon source disclosed by the Lee – Beveratos 1 combination can be disposed in an optical resonator cavity according to embodiments rendered obvious by the teachings of Shields. The motivation for disposing the nanomaterial in an optical resonator cavity is that more of the light emitted by the nanomaterial

can be collected by the optical waveguide (e.g., 1<sup>st</sup> par. on page 11 of Shields), while a cavity formed integrally with the optical waveguide can provide more mechanical stability and strength.

**Regarding claim 35**, Shields cites (e.g., 2<sup>nd</sup> and 4<sup>th</sup> par. on page 28) a well-known use of CVD for growing a variety of nanomaterials. The Examiner notes that the use of CVD for growing diamond-like films is also known (see, for example, the reference by May et al provided by Applicant in the IDS of 9/1/06).

**Regarding claims 36 and 37**, the Lee – Beveratos 1 – Shields combination renders it obvious that the optical resonator cavity can be etched in the optical waveguide and have at least one edge (parallel to the reflectors shown in Fig. 4 of Shields) at which the nanomaterial would be deposited/grown.

**Regarding claims 38 and 39**, Fig. 13 of Shields illustrates an embodiment in which a pump light beam is delivered by using free-space optics. Clearly, such a beam can alternatively be delivered using a second optical fiber. In such a two-fiber arrangement, the two fibers would have their endfaces spliced, thereby forming a closed cavity comprising the nanomaterial. One fiber would deliver the pump light beam, whereas the other fiber would collect the light emitted by the nanomaterial.

**Regarding claim 27**, Shields cites (e.g., last par. on page 25) the well-known fact that electrical pumping/excitation can be used additionally or alternatively to optical excitation. Electrical excitation has the benefit of minimizing the device footprint by eliminating the need for a pump optical source.

***Conclusion***

10. Any inquiry concerning this communication or earlier communications from the examiner should be directed to ROBERT TAVLYKAEV whose telephone number is (571)270-5634. The examiner can normally be reached on Mon - Thur 9 am - 6 pm EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Mark Robinson can be reached on (571)272-2319. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

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4/28/10